ENVIRONMENTAL CONTROL AND MONITORING REQUIREMENTS FOR THE ONTARIO PULP AND PAPER INDUSTRY

ONTARIO
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PREFACE

Most of Ontario's pulp and paper industry is covered by Control Orders describing abatement programs to be completed by approximately the end of 1985. A review of those Control Orders suggests that although environmental requirements are, and should continue to be, based largely on the specific environmental setting of a mill, there are areas where a common approach is desirable and where guidelines and/or procedures should be developed.

As present Control Orders expire, the Ministry should clearly define what further action is required. While this will be an on-going requirement as knowledge on the effects of effluents and emissions is expanded, and as technology for control improves, the Ministry should be addressing future initiatives now.

This report recommends an abatement strategy for the middle to late 1980's. If adopted, the proposals will lead to a uniform application of the Environmental Protection Act and Ontario Water Resources Act across the Province. If recommendations in this report are implemented, the pulp and paper industry will meet provincial requirements for the control of suspended solids (S.S.) biochemical oxygen demand (B.O.D.), and toxicity by 1990. There will also be substantial improvements in the self-monitoring of the industry.

Significant achievements have been attained in water pollution abatement over the last twelve years as indicated in the following table.

	1970	1982	% Change
Production	11,456 tonnes/day	12,950 tonnes/day	+13
Flow	1,858,000 m^3/day	1,561,000 m^3/day	-16
BOD Discharged	768 tonnes/day	477 tonnes/day	-38
Suspended Solids Discharged	451 tonnes/day	119 tonnes/day	-74

As new technology becomes available and as environmental knowledge is expanded, new directions will have to be considered for the industry.

BACKGROUND

The pulp and paper industry is one of the major industrial sources of pollution in the Province of Ontario. Currently, there are 28 pulp and paper mills in Ontario. The sources and nature of emissions are specific to the type of process(es) employed at a particular mill location. Major process categories include kraft and sulphite chemical pulping mills, and several variations of mechanical pulping mills producing kraft pulp, newsprint, fine paper and specialty products.

Requirements and Directions, under the Water Resources Act, and Control Orders, under the Environmental Protection Act, have been used to enforce abatement programs on this industry during the past decade. The use of Control Orders to achieve abatement in the Pulp and Paper industry was formalized into policy in 1977. In late 1977, the Ministry's abatement program was further strengthened by the implementation of the Ontario/Canada Pulp and Paper Industry Facilities Improvement Program. Under this program, the Federal and Provincial governments have contributed a total of $188 million to Ontario pulp and paper companies for mill modernization, energy efficiency and environmental improvement projects. It was agreed that the Ministry of the Environment would issue Control Orders to cover environmental proposals prior to approval of funding. This has resulted in a total commitment by the companies of $1.7 billion in capital investment. These efforts have resulted in significant environmental improvements within the industry.

Socio-economic factors are and must be considered by the Ministry during the development of all Control Orders. Factors of concern to the general public, such as site-specific nuisance

problems or the economic impact of a Control Order on a municipality, are dealt with at public meetings before Control Orders are issued. Financial matters are discussed between the Ministry and the company during the preparation of the draft Control Order. These procedures ensure that all Control Orders meet the needs of the public and the environment while ensuring that they are achievable for the industry.

AIR EMISSIONS

NATURE OF CONTAMINANTS

Odours

Kraft pulping processes result in the release of significant emissions of odourous gases called total reduced sulphur (TRS). TRS comprises hydrogen sulphide, methyl and ethyl mercaptan, and methyl sulphides. At very low concentrations (5 parts per billion (ppb) or less), these gases create offensive odours. At higher levels, TRS may darken paint, damage vegetation, or cause temporary respiratory irritation to sensitive individuals. The Ministry's ambient air quality objective for TRS near kraft pulp mills is presently 27 ppb hourly average, expressed as hydrogen sulphide. The Ministry is not aware of evidence linking chronic health effects to elevated TRS concentrations in communities near kraft pulp mills.

Sulphur dioxide (SO_2) is the air contaminant of most concern from sulphite and semi-chemical mechanical pulping (SCMP) mills. Concentrations of sulphur dioxide exceeding the Ministry's ambient air quality criterion (Regulation 296) of 0.25 ppm one-hour average, can cause adverse effects on sensitive vegetation. The burning of fossil fuels in power boilers also generates sulphur dioxide.

Particulates

Chemical recovery processes at kraft pulp mills are sources of particulate emissions. Specific sources include the recovery furnace where concentrated pulping liquor is burned and the smelt

tank in which the molten smelt is dissolved in either water or weak wash solution to form green liquor. The lime kiln, another component of the chemical recovery process, is also a major source of particulate matter.

The handling of wood chips can result in nuisance particulate emissions to nearby residential areas. The extent of these problems largely depends upon the fines content of the chips, their moisture content, storage location, and methods of chip conveyance.

A number of fuels are used by the industry for process steam, heat, and power generation. Due to increased energy costs, more hogged fuel (bark, sludge) and coal are now being utilized. Burning of these fuels can also result in particulate emissions.

Particulate emissions from pulp mills can cause nuisance and soiling effects. The ambient air quality objectives are 7 g/m^2 (grams per square metre) for dustfall (30-day average), and 120 $\mu g/m^3$ (micrograms per cubic metre) for total suspended particulate matter (24-hour average).

Another particulate emission problem is blowing foam from aeration stabilization basins. This is generally in the form of small dry particles that can be carried considerable distances by wind. This material can enter homes through open doors and windows and even through screened windows. Although one study indicates it is not a health problem, it does cause nuisance and soiling effects.

Chlorine

In kraft mills, washed and cleaned wood fibre is bleached to improve pulp brightness. During this process, there may be emissions of chlorine and/or chlorine dioxide, as well as low levels of other organic compounds associated with the bleaching process. Chlorine concentrations above the Regulation 308 limit of 300 $\mu g/m^3$ measured over a half-hour period may affect vegetation, human health and property.

Water Vapour

In some cases, water vapour emitted from paper machines is an air contaminant. In these situations, water vapour emissions near roads may cause icing and/or reduced visibility.

Noise

The debarking of logs is accomplished in drum debarkers. Noise and vibration problems may result, depending on the location of the mill with respect to residential areas, the design of foundations, and the type of equipment used.

REGULATION 308

Name of Contaminant	Conc. at point of impingement, half-hour average	Rationale for Standard or Guideline
Chlorine	300 µg of chlorine per cubic metre of air	health, vegetation damage
Chlorine dioxide	85 µg of chlorine per cubic metre of air	health effects
Dimethyl disulphide	40 µg of dimethyl disulphide per cubic metre of air	odour
Dimethyl sulphide	30 µg of dimethyl sulphide per cubic metre of air	odour
Dustfall	8,000 µg per sq. metre	aesthetic, nuisance
Hydrogen sulphide	30 µg of hydrogen sulphide per cubic metre of air	odour
Mercaptans	20 total µg of mercaptans per cubic metre of air expressed on methyl mercaptans	odour

Name of Contaminant	Conc. at point of impingement, half-hour average	Rationale for Standard or Guideline
Sulphur dioxide	830 µg of sulphur dioxide per cubic metre of air	health and vegetation
Suspended particulate matter (particulate less than 44 microns in size)	100 µg of suspended particulate matter per cubic metre of air	nuisance
Total reduced sulphur	40 µg per cubic metre of air, expressed as H_2S	odour

STATUS OF ABATEMENT TECHNOLOGY

Technology for in-plant control of air emissions and add-on abatement equipment appear to have reached a stable position. Given present day technology, all mills should be in a position of complying with the Environmental Protection Act and Regulation 308.

Wood Preparation

Good engineering design is required to prevent excessive noise and vibration from woodrooms.

Particulate emissions from chip handling and storage can be effectively controlled by a number of methods. Probably the most important factor is the control of fines within the chips. This is not only important for emission control but also for production purposes. Maintaining sharp knives on chippers is essential for obtaining good quality chips. Screening chips may be necessary to maintain a low percentage of fines. A properly designed chip conveyance system should include effective booms and deflectors to keep the chips near the ground, along with the capability of adding moisture to the chips. The location and size of chip piles also affects particulate control.

High efficiency collectors may also be installed on some digester feed systems to reduce nuisance emissions.

Kraft Pulping and Chemical Recovery

Non-condensible odourous gases from digesters and blow tanks may be collected and incinerated, either in a power boiler or lime kiln. Condensible gases and volatiles produced on pre-steaming wood chips in continuous digester systems and during cooking in batch digester systems may be recovered to produce turpentines.

Emissions from brown stock washers are considered a high volume, low concentration source of odour. The location of the mill and the resultant effect of the TRS discharges dictates the priority for control.

During concentration of black liquor utilizing multiple-effect evaporators, the vapour produced by one effect is used as the heating medium for the next. On condensation, the liquids contain TRS compounds. Contaminated condensates can be upgraded by steam or air stripping for reuse as dilution water or wash-water. The non-condensibles can then be collected and incinerated either in a power boiler or lime kiln.

Where direct contact evaporation is employed, black liquor oxidation may be used to oxidize the sulphur compounds to a more stable form. These systems should operate at 99% efficiency to ensure acceptable odour reductions. An alternate system involves the use of a specially designed indirect contact evaporator in which hot furnace gases are not permitted direct contact with black liquor. A third alternative is to provide additional capacity for concentrating black liquor prior to its entering the evaporators.

Other sources of TRS emissions within the recovery cycle are liquor storage tanks. Some mills have successfully collected these emissions for incineration.

Recovery boilers account for approximately 60% of the odourous materials generated in a kraft mill. This source can be controlled by replacing existing furnaces with low odour units

which utilize indirect concentration of weak black liquor. Alternatively, existing furnace systems may incorporate molecular or air oxidation of the black liquor. Suitable abatement can also be achieved by chemical scrubbing of furnace gases. These technologies are being used at most kraft mills in Ontario.

Recovery boilers are also a major source of particulates, mainly sodium sulphate. Two basic control methods are electrostatic precipitators and venturi-type scrubbers. Precipitators are the most efficient and commonly used method. Mills require particulate removal efficiencies of 99% plus to meet Provincial regulations. Molten smelt from recovery furnaces, when mixed with weak wash or water in the dissolving tank, also produces particulates. Scrubbers are commonly used to provide control of this source.

Another primary source of particulates are lime kilns. Various types of wet scrubbers have been used for control. To meet legislative requirements, venturi-type scrubbers are usually required. In recent years, fabric filters have been used as an alternative. Although capital costs are significantly higher, the filter provides more efficient collection of the particulate and eliminates vapour plumes.

Lime kilns can also be a source of TRS emissions. Efficient washing, to remove soluble sodium salts from the lime mud, is required to minimize the production of TRS gases in the kiln. Complete combustion in lime kilns of non-condensible gases from the sources previously discussed, must also be assured to eliminate additional emissions of TRS.

SOME TRS SOURCES IN TYPICAL KRAFT PULP MILLS

1. RECOVERY PLANT

***i) Recovery Furnaces - stack gases.
*ii) Multiple Effect Evaporators - non-condensible gases from surface condensor following last effect.
**iii) Smelt Dissolving Tanks - vent gas.
****iv) Tall Oil Plants - acidulation tank vent gas.
v) Black Liquor Storage Tanks - vent gas.

2. PULPING PLANT

*i) Digesters - relief vent gas and blow gas.
*ii) Turpentine Recovery Systems - non-condensible gases.
**iii) Knotters, Screens, Brown Stock Washers - hood exhaust stacks and seal tank vent gases.

3. RECAUSTICIZING PLANT

**i) Lime Kilms - stack gases.
**ii) Lime Slakers and Causticizers - tank vent gases.

4. OTHER

*i) Condensate Strippers - non-condensible gases.
+, **ii) Effluent Sewers or Pumping Stations - vent gases.
+,**iii) Effluent Settling Basins - surface evaporation.
iv) Black Liquor Oxidation Systems - spent air exhaust vents.

NOTES:

* = Can be incinerated in lime kiln to eliminate.

** = Use of weak wash, fresh water or stripped condensate may reduce or eliminate emissions.

*** = Low-odour design, addition of black liquor oxidation or scrubbers will reduce emissions.

**** = Scrubbers with alkaline solution will reduce emissions.

\+ = Spill control and good housekeeping keeps black liquor, and hence TRS, out of effluent.

Kraft Pulp Bleaching

The use of chlorine and chlorine dioxide as bleaching agents can result in emissions of chlorine and chlorine dioxide from the bleach plant. Existing scrubber technology based on sodium hydroxide solution or extraction stage filtrate is adequate to control these emissions.

Sulphite and Semi-Chemical Mechanical Pulping

The batch operations of sulphite pulping mills results in periodic concentrated emissions of sulphur dioxide. These emissions are produced by the burning of sulphur to produce sulphur dioxide (SO_2) for the preparation of cooking liquor and during

digester blowdown. Environmental effects of emissions may be reduced by chemical scrubbers and by staging gas release through pressure control valves during digester blowdown. The newer Semi-Chemical and Chemi-Thermal Mechanical processes produce significantly less sulphur dioxide. Chemical scrubbing can be used to control these emissions.

Paper Machines

Vapour plumes from paper machine dryers pose a difficult problem to resolve. Dispersion and condensation are two methods which can be considered when control is necessary.

Power Boilers

Emissions from boiler plants are dependent upon the type(s) of fuel used. Natural gas has been a major fuel source in recent years. Oxides of nitrogen (NO_x) are contaminants associated with its use. Efficient boiler design and other combustion modifications (e.g. staged combustion, flue gas recirculation, etc.) are capable of controlling these emissions.

A second major fuel source and one which is becoming more economical is woodwaste or hogged fuel. Associated with its use are particulate emissions. Mechanical collectors are commonly used for control, but with the number of other particulate sources associated within the mill complex, more efficient collectors have proven to be necessary to meet air regulations which relate to the aggregate levels. These include fabric filters, scrubbers and electrostatic precipitators. Oil is another fuel used by some mills which results in sulphur dioxide emissions. Use of low sulphur coal (<3% S) where coal is to be burned will reduce sulphur dioxide emissions and, if necessary, scrubbers can be added to meet standards.

With the ensuing energy crisis and higher costs of natural gas and oil, it is apparent that consumption of coal by the industry will increase. Sulphur dioxide and particulate emissions from existing boilers could be significant if uncontrolled. Low sulphur coal should be used where possible, however scrubbers may be required to meet Ministry regulations. Fabric filters, elec-

trostatic precipitators, or wet scrubbers will be necessary for adequate particulate control on coal burning installations.

FUTURE REQUIREMENTS

Kraft Mill Emission Inventory

Several existing Control Orders require kraft mills to prepare inventories of emissions of TRS, SO_2, NO_x, and particulate matter from stacks and fugitive sources. This data will help identify all major sources of emissions from mills, and will provide actual emission rates for use in dispersion modelling in the surrounding environment. The Ministry should be consulted prior to the survey being conducted to ensure that all sources of concern are tested and that sufficient data are collected to accurately assess compliance with Ministry regulations. One kraft mill has completed an odour survey in the community near its mill to assess the impact on the area residents.

Information from emission surveys determines the Ministry's position for future abatement action as well as providing useful operating information for the mill. This approach is also valuable in determining abatement requirements for mills engaged in sulphite pulping and/or combustion of solid fuels.

All pulp and paper mills shall:

i. complete and submit a report on a survey to identify and measure all known and suspected sources of odours, sulphur dioxide, nitrogen oxides, total reduced sulphur and particulate matter, and

ii. install devices or otherwise control the emission of the above contaminants to comply with Regulation 308, of the Environmental Protection Act.

iii. The terms of reference for the survey must receive prior approval from the Regional Director.

iv. Those mills with emissions in excess of Regulation 308 limits will update the survey information on a three-year cycle.

Ambient Air Monitoring and Telemetering

Ambient air monitors continuously measure contaminant concentrations after dispersion from stacks or other emission sources. Point of impingement air quality standards of various pollutants are listed in Schedule 1 of Regulation 308 of the Environmental Protection Act. Regulation 296, specifies one-hour, 24-hour, and yearly averages, which are required to protect sensitive receptors.

Historically, the Ministry has installed and maintained ambient air monitoring equipment to record pollutant levels near the more significant industrial sources in the Province. Sometimes, to prove whether or not emissions from an industry are causing environmental effects in a specific area, the Ministry has required the industry to install, operate and maintain ambient monitors.

Data from these monitors are collected by the Ministry and the results are submitted for review to the industry or published in air quality reports. Abatement would be more effective if real time data were available directly to the industry as well as the Ministry. This would allow operating changes to be undertaken immediately toward reducing excessive emissions.

Ambient monitoring data is used by the Ministry as a measure of the air quality in each community. In some cases, ambient data may be related to industrial sources.

The Ministry has required some companies to telemeter data from ambient air monitors directly to their mills so that operating personnel have up-to-the-minute knowledge of air quality at the monitoring site(s). This action effectively assists the operator in controlling the source of emission. The new Provincial telemetry system will provide the Ministry with real-time data from all ambient air monitors.

> Ambient air monitors shall be installed and operated in municipalities where pulp and paper mills emit amounts of particulate matter, TRS, or SO_2 in excess of Regulation 308 or at levels that

> give rise to public complaints. Telemetry equipment shall be installed by the company to transmit the data from these monitors directly to the mill.

Source Monitoring

Ambient monitoring is used by the Ministry to monitor air quality and point out areas of concern with respect to specific pollutants.

Source monitoring measures the concentration of a contaminant discharged from a source. Maximum ground level contaminations (MGLC) as specified in Schedule 1 of Regulation 308 are calculated by the dispersion calculation specified in the Regulation. Specific data such as stack height, stack diameter, exhaust gas temperature, mass emission rate for each contaminant, etc., are required to perform this calculation which will determine whether any given source meets the standard specied in Regulation 308.

Source monitoring can be carried out continously or periodically. A potential alternate approach to source monitoring in kraft mills may be through correlation of emission data with process parameters. This approach is now only in the developmental stage, as the dynamics of recovery furnace operation are not fully understood.

Continuous monitoring of major point sources is valuable in determining the need for abatement measures, assessing the effectiveness of abatement equipment, and in assisting process control. Stack emission data, in combination with wind speed and direction information, can relate ambient air quality to emissions. It should be recognized that source monitors represent relatively new technology: they require sample conditioning, frequent maintenance and are less reliable than ambient air monitors. Currently, three kraft mills in Ontario monitor recovery furnace TRS and opacity levels, while another mill monitors TRS and SO_2 emissions.

Several regulatory agencies in North America require that mills undertake continuous monitoring of major point sources. Parameters measured include such contaminants as TRS, SO_2, NO_x

and particulates. Mills in other jurisdictions are also required to perform stack sampling at these sources on a 3-to 5-year cycle. Stack testing provides a means of calibrating the continuous monitors and assists in proper maintainence of abatement equipment.

An alternative for monitoring of TRS is to obtain samples for laboratory analyses using gas chromatography (GC). This method is reliable and allows mills to take samples from a source with high moisture content, where continuous analysers may be ineffective or unreliable.

> Continuous monitoring devices to measure selected contaminants shall be installed on all major emission sources, such as power and recovery boilers, and lime kilns.

Reporting

The Ministry has developed a computerized system known as the Industrial Monitoring Information System (IMIS), which will compile air emission, solid waste, and water discharge data reported by major industries in the Province. The inventory is based on a 30-operating-day reporting period and includes major parameters and contaminants associated with the respective industry.

Although continuous monitoring equipment which will adequately monitor mass emission rates is expensive and requires daily maintenance, continuous monitoring equipment which will measure concentration levels is available. Regulation 308 prescribes maximum ground level concentrations (MGLC) of many pollutants. Without mass emission rates, MGLC cannot be calculated. It is suggested that, by using conventional stack testing methods in conjunction with continuous stack monitors, the Ministry, in concert with each company for each major source and parameter, establish a maximum emission concentration, based on normal operation, which will ensure the MGLC will not be exceeded. The Ministry and company involved will attempt to establish normal air flows for each stack using stack sampling data, fan speeds

etc. It is recognized that the data generated will have some error associated with it, but it will provide both the Ministry and the industry with valuable data which will be indicative of the air emissions of the various parameters under normal operating conditions and will also point out the times when emissions are high due to process upsets, equipment failure, etc. Monitors to measure the concentration of various parameters would then be sufficient. Excursions above the maximum acceptable concentration limit, and their duration, could then be reported. In the future, as equipment becomes available, continuous monitoring of emission flowrates could be an added requirement to enable calculation of mass emission rates. This approach would bring data on air emissions into line with those now monitored and reported for effluent discharges.

> All mills that are required to install continuous emission monitors on major emission sources shall maintain all recording charts on file for a period of two years and submit a monthly report to the Ministry to include:
>
> i. the maximum, minimum and average concentration of emissions from the source monitored for each working day; and
>
> ii. the concentration, range, and duration of excursions above stack emission levels as established by the Ministry on a site specific basis.

Fugitive Sources

When compliance with existing Control Orders has been achieved, odour and particulate matter emissions may still remain above legislated requirements. Work should therefore be carried out to determine the level of emissions from fugitive or small sources. Such sources include black liquor storage vents, brown stock washer vents, bleach plants and chip handling systems. To determine compliance with Provincial legislation the aggregate of all such emission sources must be considered.

> All mills shall identify areas of actual or potential concern with respect to fugitive emissions. Sources of particulate matter and odourous compounds may require site specific abatement measures.

RESEARCH NEEDS

Lime Kiln Control

Control and measurements of particulates and TRS from lime kilns is not adequate at several mills in the Province. Even with efficient scrubbing, the Ministry continues to receive complaints and observe particulate emissions. High density water plumes make continuous monitoring very difficult and can cause adverse effects to downstream receptors. Fabric filters and electrostatic precipitators have been installed at mills outside the Province and show promise in solving the problem, but evaluation of their operations has not been undertaken by the Ministry.

> The Ministry will investigate available control and monitoring technologies for lime kiln emissions which provide consistent control efficiency to emissions of particulates and TRS.

TRS Regulation

The provisional guideline for TRS is 27 parts per billion, measured as hydrogen sulphide. In locations where the guideline is being met, the Ministry continues to receive complaints of objectionable odours.

> The Ministry will review the provisional total reduced sulphur guideline and determine a standard for inclusion in Regulation 308, bearing in mind that the regulation for hydrogen sulphide, dimethyl sulphide, dimethyl disulphide, mercaptans and methyl mercaptans must also be reviewed.

Non-Traditional Parameters

Air emissions containing organic compounds such as aromatic substances, resin acids, organohalides, and phenols may be of concern. The Ministry has performed limited monitoring of emissions for these contaminants. The Ministry should determine

whether these contaminants are being discharged to the natural environment in quantities sufficient to cause potential effects on health and the environment.

> The Ministry, in concert with the industry, will undertake stack testing to determine the concentration of non-traditional compounds in air borne emissions from pulp and paper mills.

Determination of Mass Emission Rates

To obtain adequate data to assess the environmental impact of air emissions from pulp and paper mills, the Ministry requires current mass emission rates for parameters such as particulate matter, TRS, SO_2 and NO_x. Equipment currently available for continuous mass emission rate monitoring is reported to be expensive and unreliable.

> The Ministry will continue to undertake a review of current methodologies for continuous mass emission rate monitoring, bearing in mind the problems with high humidity and corrosivity in emissions from the pulp and paper industry.

WASTEWATER DISCHARGES

NATURE OF CONTAMINANTS

The volume and composition of pulp and paper wastewaters varies widely according to mill age, type, size and design. However, there are similarities in the nature of contaminants to be considered.

The traditional abatement priorities of the Ministry have been to reduce loadings of total suspended solids (TSS), biochemical oxygen demanding substances (BOD) and toxic substances, in that order.

Suspended Solids

The term suspended solids refers to solid particles contained in wastewaters which can be normally removed by filtration.

Suspended solids discharges from pulp and paper mills consist primarily of wood fibre, bark, sand and grit.

In the receiving water, solids in suspension can have a negative affect upon the photosynthetic process and can cause abrasion to the gills of aquatic species. When solids settle to the bottom they can cover the available food supplies of aquatic life and destroy spawning areas. Settled solids of an organic nature also create an oxygen demand upon decomposition. In addition, they alter benthic organism habitats, causing a reduction or disappearance of those communities. Aesthetic effects include the evolution of gases upon decomposition, which in some cases may result in the formation of floating solid mats.

Because of the environmental effects caused by suspended solids discharged into receiving waters, abatement of these material discharges have received a high priority by the Ministry. Reductions in the amount of suspended solids discharged in recent years has reduced the effects on the environment in many cases.

Biochemical Oxygen Demanding Substances (BOD)

The term biochemical oxygen demanding substances (BOD) refers to a broad range of organic compounds having the common characteristic of consuming oxygen during decomposition. When released into receiving waters, these materials consume oxygen and may lower dissolved oxygen levels in the receiver to concentrations where fish and aquatic biota cannot survive. These compounds may also contain substances that cause tainting of water and fish flesh, toxicity, foam production, and added colour to the receiving water and have bioaccumulative affects.

BOD materials are associated with both mechanical and chemical pulping activities, the latter being the most significant. Wood storage in head ponds can exert dissolved oxygen demands on a river. During the mechanical or chemical breakdown of wood substantial quantities of soluble organic components are released which can consume dissolved oxygen in the water.

Toxicity

Pulp and paper mill wastes are complex mixtures, containing typically several hundred compounds. It has been well documented that several of these compounds cause lethal and sublethal damage to aquatic organisms, as well as causing oxygen depravation in receiving waters. Resin and fatty acids from the pulping process have been considered to have a local topical effect at the gil interface but evidence is accumulating that they cause significant, sublethal, systemic damage as well. Similarly, chlorinated phenolic compounds are not only lethal but accumulate in fish and may cause sublethal damage. Other classes of toxic compounds found in pulp mill wastewaters are phenols, aromatic acids and chlorinated hydrocarbons as well as volatile substances such as hydrogen sulphide and chlorine. The principle sources of the compounds are the woodroom, pulping process, and bleaching effluents.

STATUS OF ABATEMENT TECHNOLOGY

Woodrooms

The use of dry woodrooms can reduce overall mill water use while reducing effluent toxicity by leaving the organic acids with the bark, which can then be incinerated.

Closed-cycle hydraulic debarking, using clarifiers to separate bark from water and presses to remove moisture to allow incineration of the bark, can also be used. In this case, it is generally found that fresh water must be added to the system and contaminated water disposed of. Since phenols and organics build up in the system, little environmental advantage is gained unless the solution is properly disposed of.

Kraft Pulping and Chemical Recovery

The use of spill collection and recycling facilities can reduce BOD and suspended solids losses with corresponding returns in the form of reduced fibre and diminished chemical losses.

Counter-current washing in brown stock washer systems can reduce water consumption and evaporator capacity requirements.

In some cases, replacement of batch digesters with continuous digesters and/or the use of computers to control the cooking process can result in improved process control with reduced losses of BOD and suspended solids due to spills.

Condensate stripping achieves significant BOD reductions and reduces odourous materials in evaporator condensates and turpentine underflows.

The use of improved dregs filters in causticizing plants and lime mud filters removes fine particulate normally discharged to clarifiers. These fine solids can cause clarifier inefficiencies.

Mist eliminators on evaporators produce cleaner condensate that can be recycled as wash water on brown stock washers or used as make up water in the causticizing area. Steam operated condensate stippers can be used to improve the quality of condensates for reuse in the mill.

A recent innovation in the kraft pulping industry has been the introduction of the closed cycle mill concept. This concept has not yet become proven technology although at its present state it offers significant reductions in BOD.

The system uses a salt recovery process to remove sodium chloride originating from bleachery effluents so that when the latter are recycled to the black liquor recovery process sodium chloride will not build up in the system. It also includes extensive spill collection and recycling systems to return spilled product and chemicals to the process. Expanded evaporator capacity is required to evaporate spills low in fibre or chemical and process streams that cannot be used for process water or washwater. Condensate strippers are operated at approximately 20% steam-to-condensate ratios to remove as much methanol and organic material as possible to allow discharge or recycling of a waste stream that would otherwise be high in BOD content.

Kraft Pulp Bleaching

Improvements in this area include counter-current washing for water conservation and improved screens to reduce fibre

losses. Other improvements include the partial replacement of chlorine with chlorine dioxide in the first stage of the bleaching process. This may result in less carbohydrates being dissolved with a possible small increase in yield and less chlorinated hydrocarbons and free chlorine in the discharge. Oxygen bleaching can be used to replace a portion of a conventional chlorinated bleaching system with substantial reduction in chlorine use, lower BOD and possibly less toxic bleachery effluent.

Sulphite Pulping

Reductions in BOD loadings can be accomplished by the installation of chemical recovery systems. At sites where sulphite and kraft mills operate together a cross-recovery system can be installed. Conversion of the pulping system to a high-yield, thermomechanical, or chemi-thermomechanical process also realizes significant BOD reductions. The economic situations of each mill, product quality, and degree of environmental problems will dictate the need for and type of changes undertaken at each mill.

Paper Machines

Suspended solids losses can be reduced by the use of save-alls and fine screens to recover fibre from machine white water. These systems reduce suspended solids losses to external treatment systems thereby improving the effectiveness of clarification while increasing fibre return.

In fine paper mills, separate effluent treatment systems should be installed to recover fine particle additives such as titanium oxide and talc. These fines may not settle out in conventional external treatment works.

Uncontaminated Process Water

Segregated cooling waters usually meet Ministry discharge requirements. These can be discharged untreated or recycled.

Water Conservation

Water conservation programs reduce final effluent volumes thereby decreasing the size and energy requirements of external treatment works.

Suspended Solids Removal - External Treatment

The principle external treatment methods to remove suspended solids are settling lagoons with 50% solids removal efficiency and mechanical clarifiers with a typical design efficiency of 70-80% solids removal.

These systems are quite effective under normal operating conditions but can be adversely affected when overloaded by spills of materials such as pulp and in the case of kraft mills, lime mud. Separate spill collection facilities prevent such occurrences and allow for the recycling of spilled materials to process.

Biochemical Oxygen Demand - External Treatment

Alternatives exist for various treatment systems which reduce BOD discharges. Aerated stabilization basins have been used where space is not a limitation. Where space is a limiting factor treatment of selected high strength streams by molecular oxygen systems or high rate mechanical secondary treatment plants can be used.

Spill collection and recycle systems significantly reduce BOD loadings by returning spilled materials to the process.

Toxicity - External Treatment Kraft Mills

The most effective method of toxicity removal is treatment of the effluent in an aerated stabilization basin having a minimum of five days retention time. These systems require proper design to ensure the oxidation of toxic components and BOD. Pretreatment of highly toxic streams and the exclusion of spills that could kill the bacterial population in the stabilization basin are necessary to ensure that adequate oxidation takes place.

Aesthetics - External Treatment

Major aesthetic problems include foam, color and odour. The use of submerged diffuser outfalls diminish the effects of those problems by offering the maximum degree of dispersion.

Odours in the effluent can be reduced through the use of condensate strippers utilizing low steam-to-condensate ratios.

FUTURE REQUIREMENTS

Suspended Solids and BOD

Under the Canada-Ontario Accord, Ontario has agreed to establish and enforce requirements at least as stringent as the Pulp and Paper Effluent Regulations. The Federal effluent regulations will be applied at new and expanded production facilities and the Ministry will work toward bringing all other mills into compliance as rapidly as possible. It should be noted that the Federal Regulations are currently under review and any revised Regulations will apply when promulgated.

> All new, altered or expanded mills shall meet the Federal Pulp and Paper Effluent Regulations for suspended solids and BOD, as a minimum standard, and all "existing" mills will be encouraged to make improvements to meet the criteria for new, altered or expanded mills.

The emphasis of the Ministry's water quality management program is to set effluent requirements based upon site-specific receiving water assessments. It is Ministry policy, as stated in "Water Management - Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment", that where effluent requirements, as dictated by the results of such assessments, are more stringent than the effluent requirement specified by Federal regulations, the requirements derived from the assessment shall be imposed.

> The Ministry, with the assistance of industry, will carry out base line receiving water assessments for all mills, to determine the effects that mill wastewaters are having upon receiving waters. If the effluent requirement determined by the receiving water assessment is more stringent than the effluent requirement stipulated in the federal or provincial effluent regulations or guidelines, the requirement derived from the assessment will be imposed.

In reviewing existing Control Orders, a wide variety is evident in the method of expression of imposed limits. In cases where receiving water quality determines allowable limits, the

daily discharges of BOD and suspended solids should be averaged over a maximum of 30 consecutive working days. This will allow for the averaging of the daily fluctuations that take place at pulp mills. Shorter averaging periods can be used when it can be demonstrated that effluent quality does not fluctuate excessively or where required for the protection of the environment. This average should be lower than the limit required to protect the receiving water as defined by the receiving water assessment.

To provide a higher degree of protection, a maximum daily load for BOD and suspended solids should be established on a site specific basis. This loading should reflect variations in mill operation. Under normal operation, with no spills or process upsets, the daily load for these parameters may fluctuate ±75% in the case of kraft mills and by a smaller percentage for other plants such as finishing mills. It is possible, with sufficient daily data, to determine the normal fluctuations at each mill. The maximum daily load for each parameter under normal operation that can be achieved 99% of the time at each mill should be established as the maximum daily loading not to be exceeded as a further level of protection. This will encourage mill personnel to take steps to ensure that spills and upsets are kept to a minimum and that all corrective measures are promptly initiated.

> The Ministry will establish for all mills, requirements for total suspended solids and BOD in the final effluent to be expressed in terms of
>
> i. an allowable number of tonnes per day, based on a 30-consecutive operating day average; and
>
> ii. a "never to exceed" maximum daily loading in tonnes per day.

Toxicity

Presently, the Federal Government and Ministry of the Environment utilize different criteria to establish compliance regarding toxicity. To provide adequate protection for the environment one toxicity criteria and test method should be used. Federal Regulations require the survival of more than 80% of the

test fish in 65% effluent concentrations over a 96-hour period. Ministry of the Environment guidelines require greater than 50% survival in 100% effluent concentration over the same period.

A problem with the Federal toxicity requirement is that the test merely yields a pass/fail result. It is not quantitative in the sense of showing progress in toxicity reductions. This problem is compounded by the fact that when mills reduce water consumption, they are often unduly penalized by the production of more toxic effluents streams. At the same time however, mills which have excessive water usages derive dilution benefits. This section of the Federal Regulation is also currently under review.

As a means to overcome this situation, the use of a "Toxic Contribution" concept is recommended. This concept requires that standard water use figures be established for various process types (i.e., cubic meters of water used per tonne of product produced). The standard water use figure is then multiplied in the case of the LC_{50} criteria, by the reciprocal of the LC_{50} x 100 to calculate the toxic contribution. The use of this concept would put all mills on the same basis for toxic evaluation.

$$\text{Toxic Unit} = \frac{100}{LC_{50}}$$

Toxic Contribution = Toxic Unit X cu. metres of effluent per tonne of pulp.

The Toxic Emission Rate, which is obtained by multiplying the Toxic Contribution by the mill production in tonnes per day, can be used to relate the impact of the toxicants on the receiving water.

Toxic Emission Rate (T.E.R.) = Toxic Contribution X mill production in tonnes/day.

> All kraft mills shall be required to meet a 96-hour fish LC_{50} of 100%. The Ministry should establish a standard water use figure for various process types to be used along with some variation of the toxic contribution concept.

Aesthetics

Blowing foam and odour problems associated with effluent discharges from aerated stabilization basins at kraft mills can

be reduced by preventing liquor spills, discharges of soaps, and foul condensate losses from entering wastewaters. Secondary methods for the control of foam include the use of foam barriers, defoamers, water sprays, and submerged diffuser outfalls. Since odourous emissions and blowing foam are expected with the operation of aeration lagoons, appropriate separation distances should be maintained from residential areas.

> Mills with demonstrated blowing foam or odour problems shall take steps to reduce or minimize foam and odour problems associated with wastewater effluents.

The use of submerged diffuser outfalls provide improved dispersion of effluents and reduce or eliminate visible surface plumes and foam. At most mills, this is an important step in the elimination of aesthetic problems.

> Mills shall install submerged diffuser outfalls where it has been established that improved dispersion will benefit the local aesthetics and minimize the area affected by the effluent.

Mixing Zones

It is presently Ministry policy that mixing zones may be used as a means of allowing a limited area of a receiving water to be used for dilution. The mixing zone concept is not to be deemed as an alternative to adequate treatment. In cases where the receiving water is used for recreational purposes or as a potable water supply, it is beneficial to establish boundaries where Provincial water quality objectives must be met. In practice it is difficult to define boundaries owing to significant variations which occur with effluent plumes as they are affected by shifting winds, water currents and other phenomena. As a result, mixing zones tend to become large to account for various plume situations which might arise. If these conditions are not accounted for, a major enforcement problem is encountered in that violations could be attributable to the effects of natural phenomena.

> The Ministry will restrict the application of mixing zones, as applied to the pulp and paper industry, to use as a planning tool, as opposed to defining regulatory boundaries.

Receiving Water Assessment

To assess the impact of effluent discharges following major projects it is desirable that water quality assessments be completed. The timing of these studies will vary both with the nature of the abatement project and the predicted effects on the receiving environment. These assessments should include water and sediment analyses, vegetation and biota definitions including a population distribution analysis of indigenous organisms, the assimulative capacity of the receiving water and the human uses of the environment being impacted. These types of analyses indicate the true environmental conditions and assist in the identification of effluent requirements.

> Where deemed appropriate by the Ministry, mills shall conduct water quality assessment studies following the completion of major environmental projects or process changes. The terms of reference and timing for the study shall receive the prior approval of the Regional Director.

Lagoon Groundwater Monitoring

The use of settling lagoons and aerated stabilization basins can be expected to increase in the future. With proper design, these facilities should be impervious. However, contamination of groundwater is a possibility. Monitoring wells should be installed at all of these facilities to monitor groundwater quality.

> Mills shall monitor effluent lagoons and aerated stabilization basins for groundwater contamination in a manner acceptable to the Ministry.

Mill Effluent Monitoring and Reporting

In 1968, the pulp and paper industry commenced voluntary submission of quarterly effluent quality monitoring reports to the Ministry. These reports contain production, average wastewater flows, and calculated loadings with respect to losses of

total suspended solids, BOD and total dissolved solids. The results contained in the reports, now submitted monthly, have been used extensively by the Ministry for statistical purposes. The data has also been used for negotiating abatement programs and as a means to monitor compliance of imposed limits.

A review of current flow measuring practices shows that a variety of flow monitoring instrumentation and techniques are in use. The Ministry has little assurance as to the accuracy of mill supplied flow data, even though conventional flow measurement devices are quite capable of providing suitable information.

Proper flow monitoring equipment can be calibrated to within 5-10% precision which is adequate for most installations. Critical to achieving this accuracy is the proper installation, maintenance and calibration of the flow measurement devices and their associated recording equipment.

All mills shall:

i. obtain Certificates of Approval for all new flow measurement equipment and associated recording devices,

ii. ensure that existing flow measurement equipment is properly installed,

iii. perform regular inspections by qualified personnel to ensure continuous normal operation of flow measurement devices and recording equipment and maintain an inspection log,

iv. carry out an annual detailed check and calibration of the flow monitoring equipment and submit a report of this calibration to the Ministry, and

v. in cases where the validity of reported flow data is suspect, carry out a calibration check by an independent means approved by the Ministry.

The manner and frequency of sample collection and the method employed for analysis affects the validity and accuracy of data. Current sampling practices at Ontario mills vary considerably. A review of current methods of analysis and quality control in the

industry shows that a variety of analytical methods are in use. There appears to be a lack of quality control which would ensure reliable and consistent data.

To obtain representative effluent data, samples should be composited over a period of time and reflect changes in quality and flow over that period. Grab samples provide only an instantaneous measurement of quality, and even composite samples where flow rates vary may not be representative. A more acceptable method is to obtain samples proportional to flow.

> Flow proportional samplers shall be installed on all final effluents. In cases where a company can prove there is little change or fluctuation in effluent quality, an exemption can be requested from the Ministry.

To ensure the generation of reliable data, the Ministry must be aware of and confident in the analytical methods in use by the mills. Mills should also be required to participate in quality control and quality assurance programs.

> All mills shall employ analytical methods approved by the Ministry for the determination of all contaminants measured and reported to the Ministry.
>
> The Ministry will establish a formal program of analytical quality control and quality assurance whereby, six times per year, Ministry and mill analytical data is compared, by the analysis of "split" duplicate samples of all final wastewater effluents.

A common and compulsory data reporting program should be established. This will be facilitated by the Ministry's Industrial Monitoring Information System (IMIS) now under development. Under the IMIS, daily monitoring data will be submitted to the Ministry on a monthly basis, however only monthly averages will be entered into the computer system. Production data will be considered as proprietary information.

Aside from monitoring traditional parameters, it is desirable to monitor other parameters to provide information to abatement personnel for assessing the operation of mills.

Other parameters which should be considered are:

- pH, which can be continously monitored and recorded to provide information indicative of spills.
- Dissolved organic carbon (D.O.C.) can be conveniently monitored and is a more relevent test than dissolved solids for pulp and paper mill wastewaters. In some cases, there may exist a D.O.C./BOD relationship, which would provide a more immediate indication of effluent organic quality rather than waiting five days for BOD results. This would place the industry in a much better position to react to process upsets.
- Conductivity can be continuously monitored at reasonable cost and is an indicator of process upsets and spills.
- Chemical oxygen demand (COD) is not susceptible to many of the interferences of the BOD test and results are produced in hours rather than in five days. However, the COD test does not represent the true oxygen demand found in the receiving water and may not be a valid replacement for the BOD test.

Mills*** shall submit a monthly report containing daily analytical results and monthly averages as per the following table. The report shall be signed by a responsible company official.

Parameter	Units	Information Req'd	Sample Type
Flow	m^3/day x 10^3	daily total	continuous
Production*	tonnes/day	daily, by product	
BOD_5	mg/ℓ, tonnes	daily average	24 hr. comp.
COD, DOC or TOC**	mg/ℓ, tonnes	daily average	24 hr. comp.
T.S.S.	mg/ℓ, tonnes	daily average	24 hr. comp.
pH	pH units	daily max/min	continuous at kraft mills
Conductivity	µmhos	daily max/min	continuous at kraft mills
Temperature	°C	daily maximum	(continuous in receiving
Dissolved Oxygen	mg/ℓ	daily minimum	waters during critical periods if required)

* Proprietary.
** The Ministry will entertain requests to establish correlations between BOD and DOC or TOC analyses.
*** Non-pulping and non-reovery mills may request a reduced sampling frequency.

Although it is not feasible to routinely monitor mill wastewaters for all conceivable parameters, it is desirable to inventory the following parameters on an annual basis.

> The Ministry will obtain a composite sample of all final mill effluents for an annual scan for the following parameters:
>
> - Dissolved Organic Carbon
> - Sulphates
> - BOD_5
> - Conductivity
> - Chemical Oxygen Demand
> - Phenol Speciation
> - Aromatic Acids
> - Chlorophenol Scan
> - Phosphorus
> - Total Phenols
> - pH
> - Solids (Total, Suspended, Dissolved)
> - Chlorides
> - Fatty Acids
> - Resin Acids
> - Organo Chlorine-Pesticide Scan

Presently, the only formal active mechanism for toxicity monitoring in Ontario is a five-year Federal program which commenced in 1980 to evaluate progress in the pulp and paper industry in achieving compliance with Federal toxicity requirements. Although some mills do arrange periodic toxicity testing on their own, a more concerted and formalized effort is required to determine the status of toxic discharges in the industry. This would serve to monitor the effects on toxicity reduction as abatement programs are completed.

> All mills shall conduct quarterly toxicity tests on all final effluents. The acceptable method is the 96-hour/LC_{50}/100% toxicity test as described in the M.O.E. test protocol, using a minimum four hour composite sample. Mills which demonstrate a consistent, non-toxic effluent for a period of two years may conduct toxicity testing on an annual basis.

RESEARCH NEEDS

With respect to wastewater quality and control there are several areas where the need for further investigation or research

is evident. Several of these concerns are:

- A standardized total phenol analytical technique should be established.
- Standard water use figures based on up-to-date technology should be established for each major pulping process. This information is needed in conjunction with the toxic unit concept and for use in optimizing the operation of treatment works.
- Epidemiological studies relating to the bacteriology of pulp and paper mill effluents.
- Investigations into the use of DOC or TOC analyzers or other techniques as a replacement for the BOD test for pulp and paper effluents should be undertaken.
- Investigations into the identification of compounds contained in wastewaters that cause taste and tainting problems in fish and odours in drinking water supplies.
- Investigate the implications of components found in detailed analyses of air and water discharges.

SOLID WASTE DISPOSAL

NATURE OF CONTAMINANTS

Solid wastes generated by the industry include bark removed from logs prior to chipping and waste treatment sludges containing bark fines, wood fibre, sand and grit. Solid wastes produced in lesser amounts include waste paper and packaging materials and depending upon the type of pulping and paper making process employed, inorganics such as lime mud and various spoiled chemical additives.

The principal method of disposal of these wastes is landfilling. Inherent problems of open nuisance fires, the production of methane which is a known hazard to adjacent closed structures, and the generation of leachate containing dissolved organics from

woodwaste can result. Effluents generated are characteristically toxic to aquatic life and can cause taste and odour problems in surface water and groundwater supplies.

STATUS OF ABATEMENT TECHNOLOGY

In recent years, rising energy costs have forced the industry to actively pursue energy recovery from woodwaste with the result that several mills now operate woodwaste boilers for energy recovery. Nevertheless, most mills continue to direct large volumes of woodwaste and miscellaneous other materials to landfill sites, which are usually Company owned.

Problems posed by open nuisance fires are controllable by ensuring that when a fill area reaches its final elevation, a suitable layer of inert material is applied and compacted as soon as practicable.

Complications arising from methane generation are principally a matter of poor siting.

Leachate generation offers the most serious potential for environmental damage. It is inevitable that leachates will be generated from landfill sites. Proper siting and operating practices greatly reduce the quantity which must be contended with.

FUTURE REQUIREMENTS

In comparison to abatement efforts directed toward the treatment and/or control of mill wastewaters and air emissions, existing Control Orders contain few requirements specific to the handling and disposal of solid wastes. Under existing orders there is one requirement to implement a leachate monitoring program, one to provide sludge disposal in a manner acceptable to the Director and two requirements for covering and rehabilitation of landfill sites.

It would appear that problems associated with present solid waste disposal practices in the industry are few. However, in recent abatement efforts for this industry, the matter of solid waste disposal has been considered secondary to resolving the high profile and immediate concerns related to wastewater discharges and air emissions.

Problem Identification

Action should be taken to bring the matter of solid waste disposal in line with programs for wastewater discharges and air emissions.

> The Ministry will undertake a survey of all active and abandoned solid waste disposal sites serving the pulp and paper industry to include:
>
> i. actual and potential concerns relating to nuisance fires and complications with respect to methane generation,
>
> ii. the deposit of unlicenced waste,
>
> iii. the existence, course of travel and environmental impact of any identifiable surface flowing leachates and,
>
> iv. the probable consequences of groundwater contamination.

Site Management

Subsequent to the survey, action should be taken where necessary to require compliance with the terms of the site Certificate of Approval and other applicable provisions of the Environmental Protection Act and Regulation 309. To achieve this end, disposal activities must be carried out in conformity with a management plan.

> All mills operating active disposal sites shall be required to submit a Site Management Plan acceptable to the Regional Director to include but not necessarily limited to:
>
> i. location and planning concerns,
>
> ii. types of waste certified for deposit
>
> iii. detailed description of the operation, and
>
> iv. closure procedures.

All waste sites not currently certified should be upgraded by the owner and inspected by the Ministry to ensure compliance

with Regulation 309. This will ensure that wastes deposited in these sites are appropriate to the site and are being properly managed for the protection of the public and the environment.

> All operating sites not presently certified under Part V of the Environmental Protection Act, shall be upgraded, allowing the Ministry to issue Provisional Certificates of Approval.

Leachate Control

Identified leachate problems require collection to a common point for treatment prior to discharge. Technology for the treatment of contaminated leachates from woodwaste sites is synonymous with the types of external treatment works employed for the removal of BOD and toxicity from pulping wastewaters. This may present the opportunity at mills employing such works to collect and treat leachates jointly with pulping wastewaters. A variation of this approach is in use at one Ontario mill whereby leachates are periodically collected and hauled for disposal in the municipal sanitary sewer system. This can only be done with the approval of the municipality.

> Mills with waste disposal sites identified as having off-property flowing leachate discharges shall make provisions for leachate collection at a common point. At sites where leachate demonstrates an environmental impact, mills shall install treatment works or make suitable arrangements for control.

Monitoring and Reporting

It has not been the practice of the Ministry to require reporting of the types and amounts of wastes disposed of by landfilling. This is necessary to enable the Ministry to monitor compliance with Certificates of Approval in terms of the amounts and types of materials allowed for deposit. Knowing the effective capacity of the site and the actual rate at which its capacity is being consumed provide an indication of the lead time required to enter into discussions with mills concerning acceptable closure procedures and new site planning.

> For each active disposal site, all mills shall provide a monthly report stating the types and volumes of waste deposited in the site over the previous reporting period.

To ensure the protection of water supplies, the Ministry should require routine monitoring and reporting of leachate quality or for that matter groundwater quality where there is a potential for contamination of existing or possible future water supplies.

> Mills with active or abandoned solid waste disposal sites, having off-property leachate discharges or the potential for consequential groundwater contamination, shall be required to institute a monitoring program to the satisfaction of the Ministry.